Lawrence Livermore National Laboratory

PROGRAM UPDATE - AUGUST 2003

Laser Science & Technology

Dr. Lloyd A. Hackel, Program Leader

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Laser Peening Improves Fatigue Life of Aluminum Components for USAF

Under the support of USAF's Aging Landing Gear Life Extension Program, LS&T has been working with UC Davis, the Ogden Air Logistics Center Landing Gear Engineering Branch (OO-ALC/LILE), and Metal Improvement Company, Inc. (MIC) to evaluate the advantages of applying laser peening (LP) to improve the performance of landing gear components for the USAF. Using test coupons made from the same high strength aluminum alloy (7049-T73) as the trunnion (Figure 1), a part of the main landing gear on the USAF's T-38 aircraft, we systematically studied the effects of laser peening on the trunnion's fatigue life and stress corrosion cracking (SCC) characteristics. The results clearly show that laser peening can significantly improve the fatigue life of this component, while at the same time improving its resistance to SCC.

Since the trunnions are currently treated with a shot peening (SP) treatment, an additional goal of this study was to compare the two surface treatments (LP and SP) and to also investigate the potential effects of applying laser peening to previously shot-peened specimens. Fatigue tests at three different load levels near the service stress were performed. All three surface treatment techniques (LP, SP, and SP+LP) increased the fatigue life of the test specimen but the greatest benefits appear to come from the laser peening treatment (Figure 2). Additionally, the benefits of each of the surface treatments increased at longer fatigue lives (lower maximum stress).

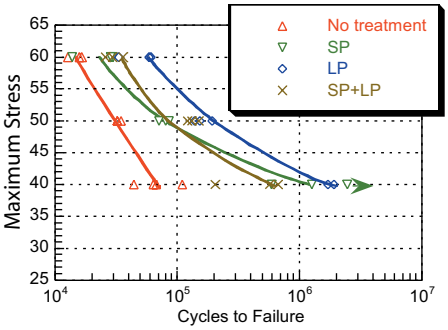

Figure 2. Stress life plot for 7049-T73 coupon tests.

SCC tests were performed on C-ring specimens made from 7075-T6 aluminum. The same surface treatments as above were used (LP, SP, SP+LP) along with a control case of no surface treatment. The untreated C-ring specimens all showed clear evidence of SCC and cracked in half in the caustic environment after 11, 13, and 23 days, while none of the treated specimens cracked throughout the entire test duration of 60 days. Although this test was not conclusive in ranking the benefits of LP over SP with regard to SCC, it did clearly show that LP is an effective tool to enhance the performance of untreated specimens against SCC. We are currently performing similar laser peening and fatigue tests on actual T-38 trunnions. Since the fatigue coupons were specifically designed to have a fatigue performance similar to the T-38 trunnion, it is expected that a similar life extension is achievable on the actual part. The estimated cost savings to the USAF (due to a reduction in the replacement costs and maintenance and inspection time) will be on the order of tens of millions of dollars.

Commercialization of Laser Peening

While the USAF development work continues, laser peening was also introduced this past year into commercial production by Metal Improvement Company, our Cooperative Research and Development Agreement partner. The laser peening system was deployed to solve an important fatigue failure problem in high-value commercial jet engine components (Figure 3). Since commercial introduction in May 2002, aircraft worth billions of dollars are now in service with laser-peened parts—saving millions of dollars per month in aircraft maintenance costs, millions more in parts replacement costs, and all the while greatly enhancing safety.

—A. Demma, M. Lee, A. DeWald, J. Rankin, and H.-L. Chen

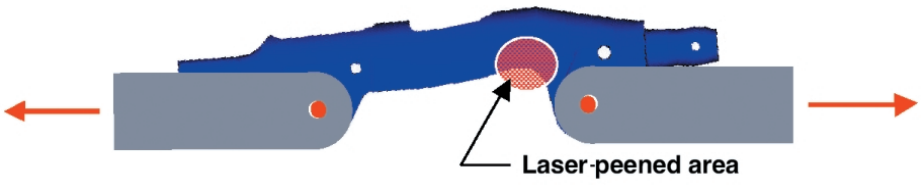

Figure 1. A trunnion, part of a USAF's T-38 main landing gear.

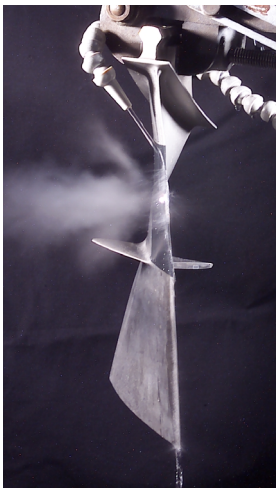

Figure 3. A jet engine fan blade being peened by laser to improve fatigue life.

For comments about content of the *LS&T Program Update*, contact Dr. Hao-Lin Chen (925) 422-6198.
To get on the mailing list of the *LS&T Program Update*, send a request to Dr. Hao-Lin Chen, chen4@llnl.gov
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